Global Ocean Data Assimilation System (GODAS)

D. Behringer

GFDL-NCEP Ocean Modeling Meeting
NCWCP
November 30, 2012

Outline

- 3dvar
- Versions
- Examples
- LETKF
- Remarks

3dvar

W3 – precursor to GODAS

- An application of Derber and Rosati (1989)
- Built on MOM2
- 2dvar in each model level + vertical smoothing
- Assimilated only temperature profiles
- Used with a Pacific Ocean model

GODAS/M3

- Built on MOM3, code rewritten from W3
- 3dvar
- Assimilates T and S profiles and altimetry
- Used with a quasi-Global Ocean model
- Operational

GODAS/M4

- Built on MOM4, code rewritten from GODAS/M3
- Fortran 90, MOM4 data structures, mpp
- Used with a full Global Ocean model
- Operational

3dvar - continued

- Synthetic salinity profiles are generated offline from temperature profiles and TS-correlations for the years prior to the Argo era.
- Altimetry is assimilated via an observation operator based on a linearized steric height calculation.
- The horizontal background error covariance approximates a Gaussian function. The zonal and meridional scales of the function decrease with increasing latitude and the zonal scale is stretched with respect to the meridional scale by a factor of 2 within 10 degrees the equator (880 km x 440 km at the equator, 220 km x 220 km at 60^{o} N). The vertical covariance also approximates a Gaussian function. The vertical scale increases with depth as the vertical grid cell dimension (~10 m near the surface, ~224 m at 950m). The estimated error variances for temperature and salinity are scaled by the square root of the local vertical gradient of the respective fields taken from previous model output.
- Quality control is automated and done offline in a preparation step.

Versions

GODAS/M3 – uncoupled

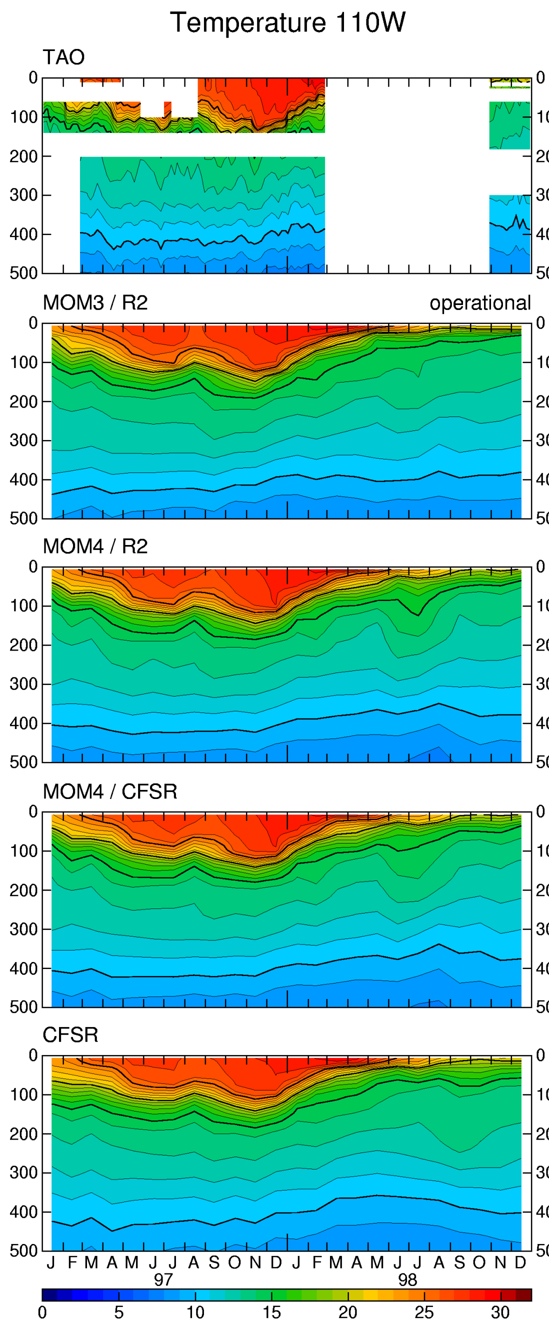
- Quasi-global, 74.5°S-64.5°N
- Horizontal resolution: 1°x1°, 1/3° N-S in equatorial zone
- Vertical resolution: 40 levels, 10m thickness to 220m, Z_{max}=4737m
- Assimilates SST, SSS, XBTs, Argo, TAO, TRITON, PIRATA, RAMA, TOPEX, Jason-x, gliders
- Provided ocean initial conditions to CFSv1
- Operational on CCS (Power6)
- Will be ported to WCOSS (Intel–Linux)

GODAS/M4 – coupled (MOM4p0), uncoupled (MOM4p1)

- Global, tri-polar grid
- Horizontal resolution: 1/2°x1/2°, 1/4° N-S in equatorial zone
- Vertical resolution: 40 levels, 10m thickness to 220m, Z_{max}=4737m
- Assimilates SST, SSS, XBTs, Argo, TAO, TRITON, PIRATA, RAMA, TOPEX, Jason-x, gliders
- Ported to Zeus, Gaea
- Coupled version is part of the CFSv2 (MOM4p0)
- CFSv2 is operational on CCS (Power6)
- Will be ported to WCOSS (Intel–Linux)

Examples

- Comparison of GODAS/M3 and GODAS/M4 versions
- Argo observations and the AMOC in GODAS/M4



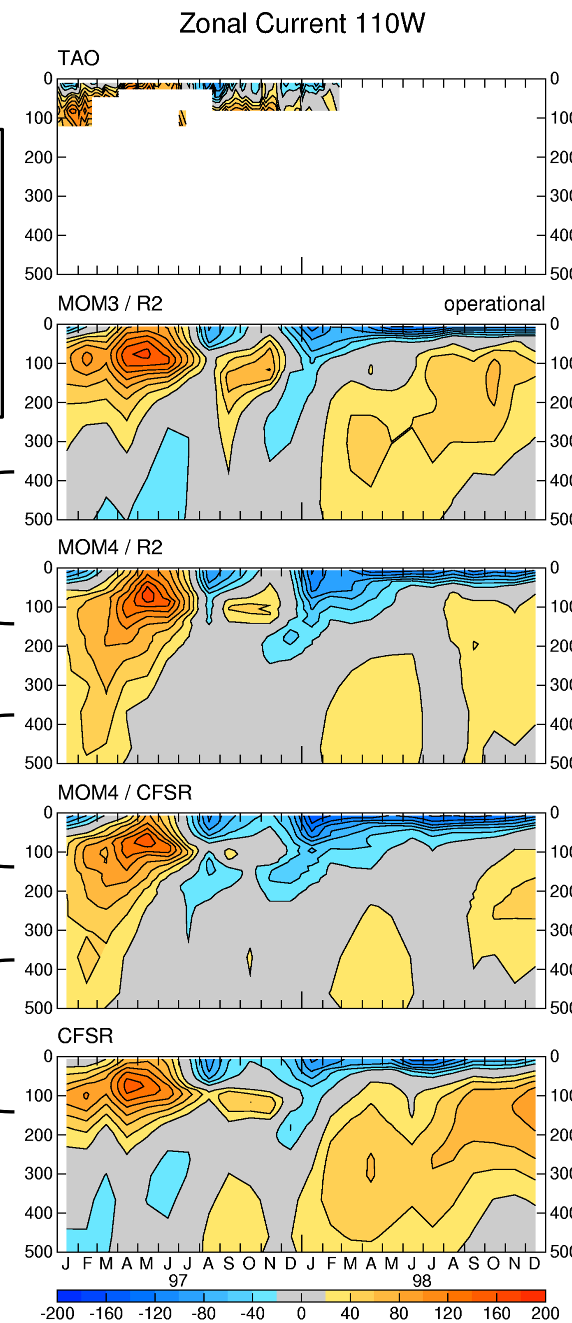
Commonality of GODAS versions during El Nino-La Nina of '97-'98

- Velocity data are not assimilated
- Altimetry withheld from these runs
- Currents show greater differences than temperature
- Uncoupled GODAS/M4 versions are most similar

Two forced by NCEP-DOE R2, but use different models: MOMv3 vs. MOMv4

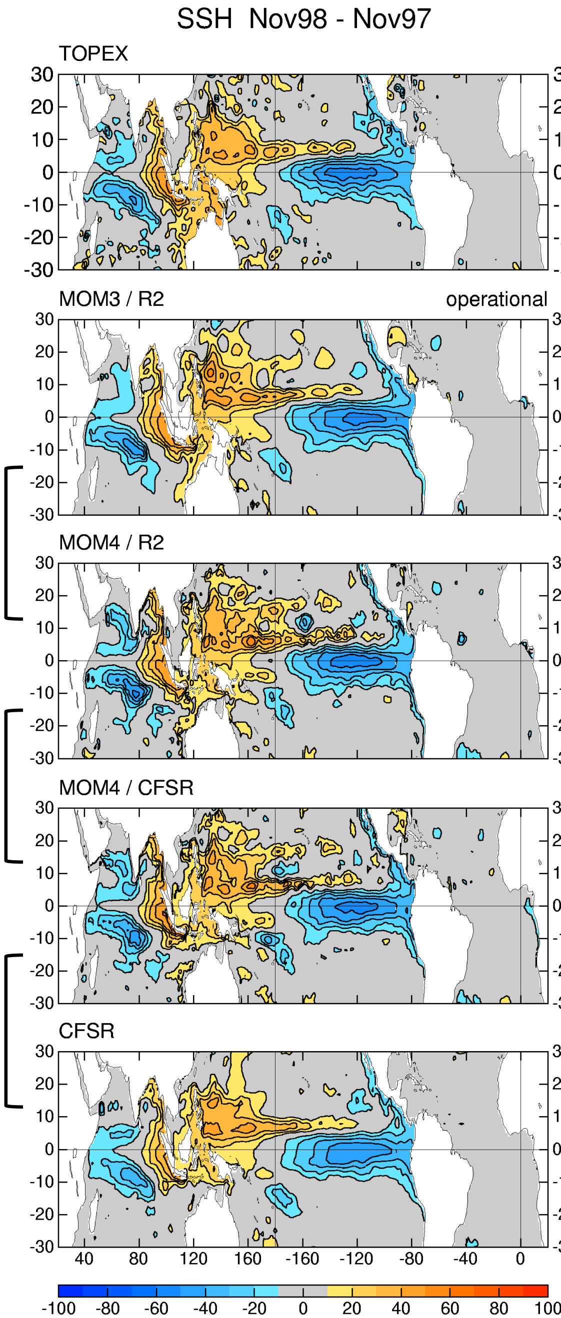
Two use the same model: MOMv4, but use different forcing: R2 vs. CFSR

Two use the same model: MOMv4 and forcing: CFSR, but are uncoupled vs. coupled



Commonality among versions of GODAS SSH: La Nina ’98 minus El Nino ’97

- Altimetry withheld from these runs
- The 3 uncoupled versions are most similar to each other and to TOPEX
- The coupled version has a similar pattern but is slightly weaker



Two forced by NCEP-DOE R2, but use different models: MOMv3 vs. MOMv4

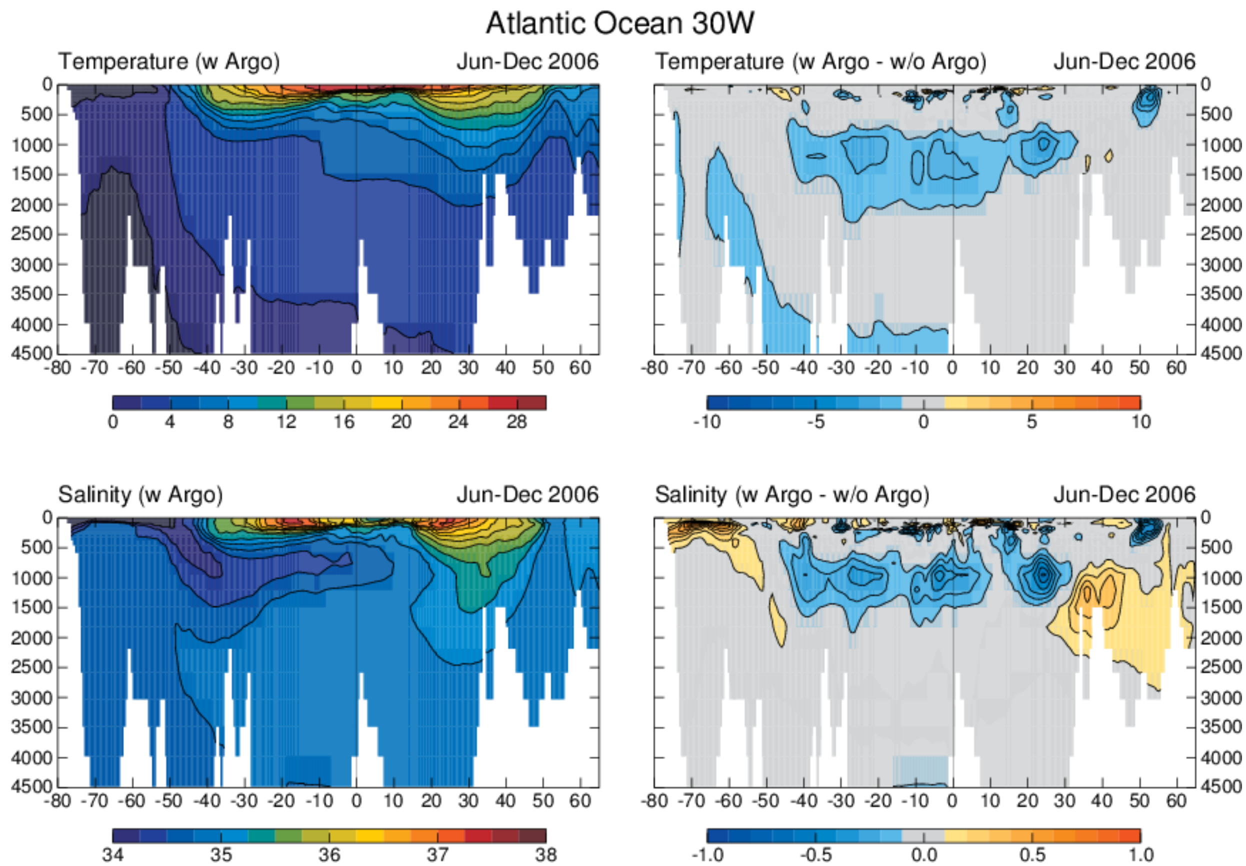
Two use the same model: MOMv4, but use different forcing: R2 vs. CFSR

Two use the same model: MOMv4 and forcing: CFSR, but are uncoupled vs. coupled

Atlantic 30°W Section Jun-Dec 2006

Temperature

Salinity

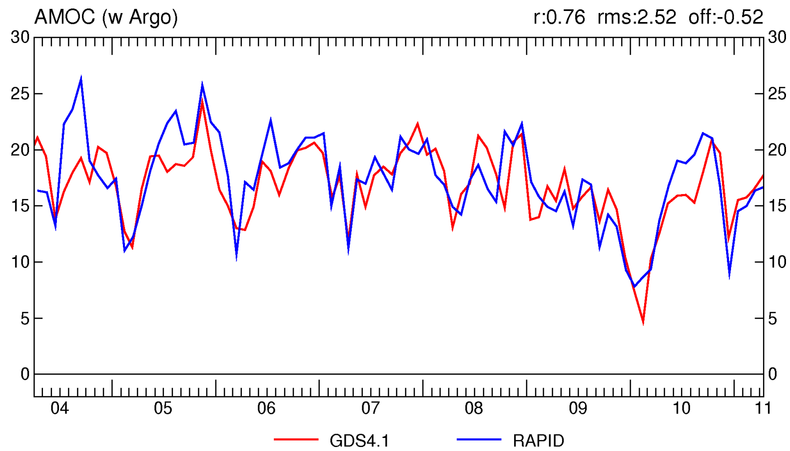


GODAS/M4
w. Argo
w. bias corr.

GODAS/M4
(w Argo – w/o Argo)

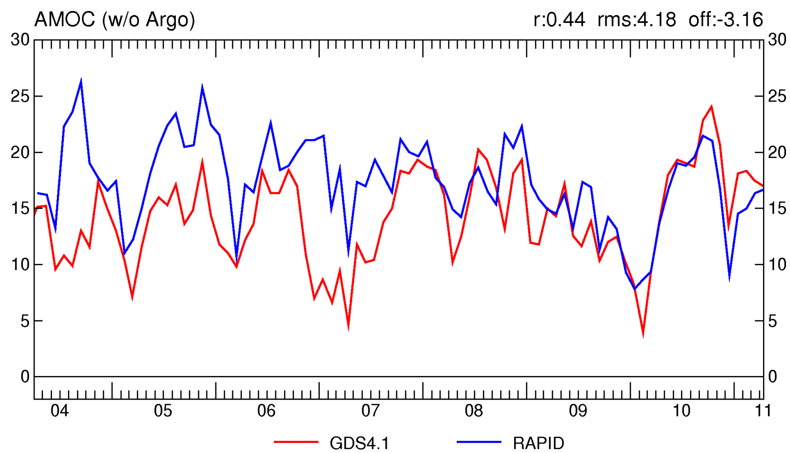
Atlantic Overturning Transport (Sv)

GODAS (red)
30-35ºN
w. Argo



Rapid (blue)
26.5ºN

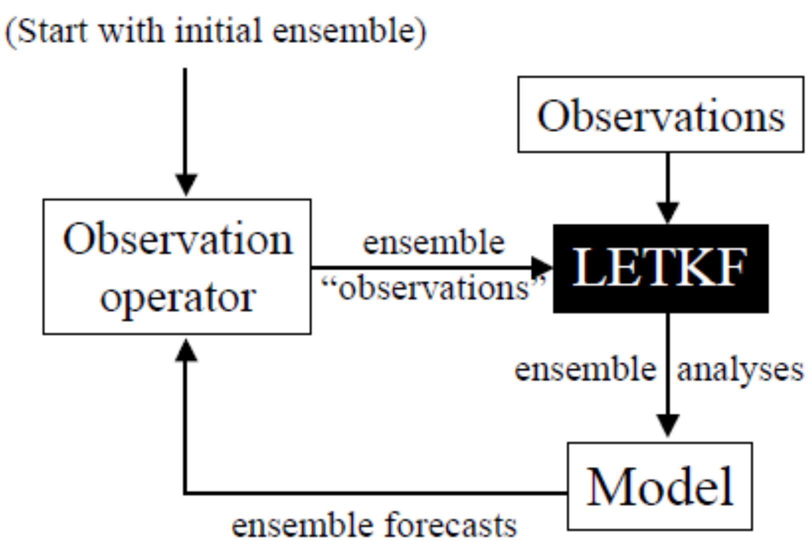
GODAS (red)
30-35ºN
w/o Argo



Local Ensemble Transform Kalman Filter (LETKF)

- Collaboration between NCEP and UMD
- Jim Carton and Steve Penny
- Built on MOM4p1
- Developed within NCEP computing environment
- Currently being evaluated vs 3dvar
- Next step is a hybrid variational ensemble system

Local Ensemble Transform Kalman Filter (Ott et al, 2004, Hunt et al, 2004, 2007)



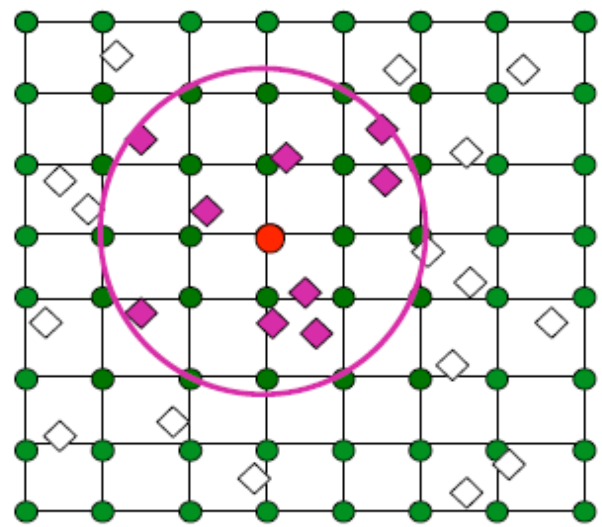
- Model independent (black box)
- Obs. assimilated simultaneously at each grid point
- 100% parallel: very fast
- No **adjoint** needed
- **4D LETKF extension**

Localization based on observations

Perform data assimilation in a local volume, choosing observations

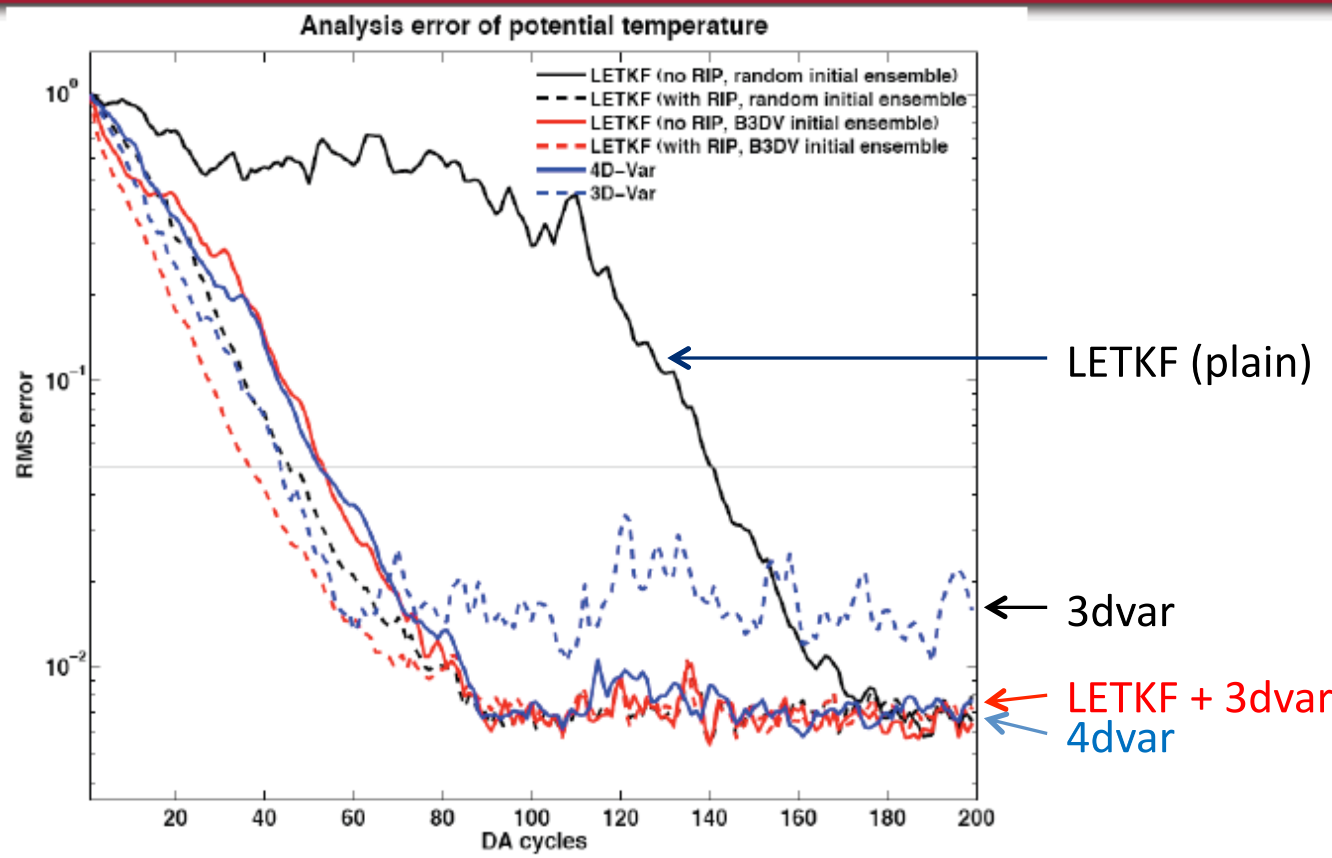
The state estimate is updated at the central grid red dot

All observations (purple diamonds) within the local region are assimilated



E. Kalnay 9/2011

Results with a QG model



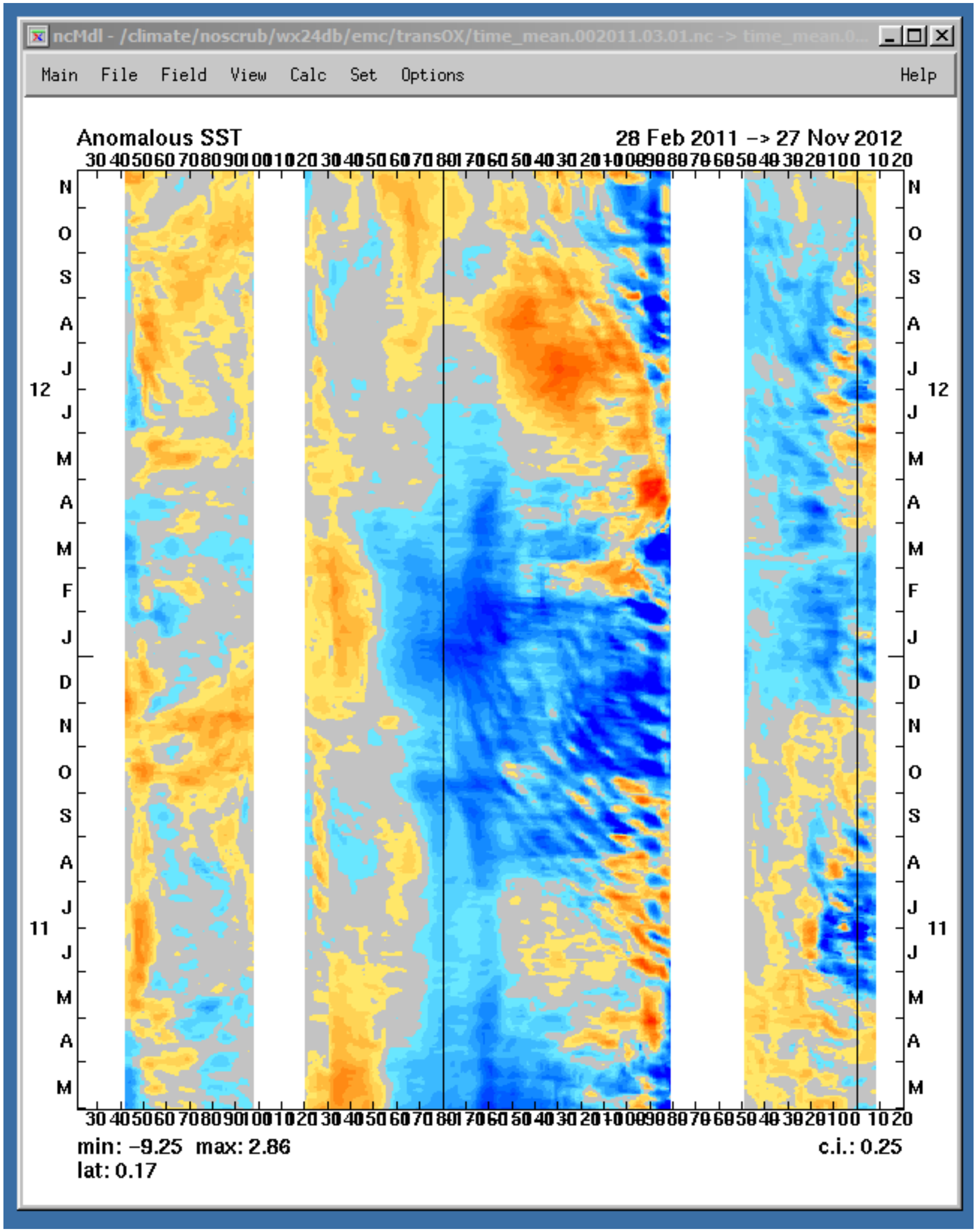
Spin-up depends on initial perturbations, but RIP works well even with random perturbations. It becomes as fast as 4D-Var (blue). RIP takes only 2-4 iterations.

E. Kalnay 9/2011

Remarks

- NCEP will need to “unify” its ocean modeling. In the short term, a single ocean model is probably not a reachable goal. LETKF and 3dvar could be made more modular. NEMS is the place to start.
- We need to be realistic about human resources. We will need to continue collaborations with outside groups.
- We also need to be realistic about computing resources. The resolution of an ocean ensemble will be set by what will fit into the operational suite.
- What is the resolution needed to advance ENSO forecasting?
- Any future re-analysis cannot have as its only purpose the calibration of seasonal forecasts.
- We will need to support the global observing system with OSE’s and near real-time monitoring.

End


ncMdl - /climate/noscrub/wx24db/emc/transOX/time_mean.002011.03.01.nc -> time_mean.0...
Main File Field View Calc Set Options Help
Anomalous SST
28 Feb 2011 --> 27 Nov 2012
min: -9.25 max: 2.86
lat: 0.17
c.i.: 0.25

Examples comparing GODAS versions

SST